The Advance Communication Technology Satellite (ACTS) Ka-Band Experience

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Outline of Presentation

- **Introduction to Rain Attenuation and Systems Effects**
- **System Availability: Theory vs. Experiment**
- **Experiment Descriptions**
- **Experiment Results**
- **Conclusive Remarks**

FADE CHARACTERISTICS

Rain Induced (random)

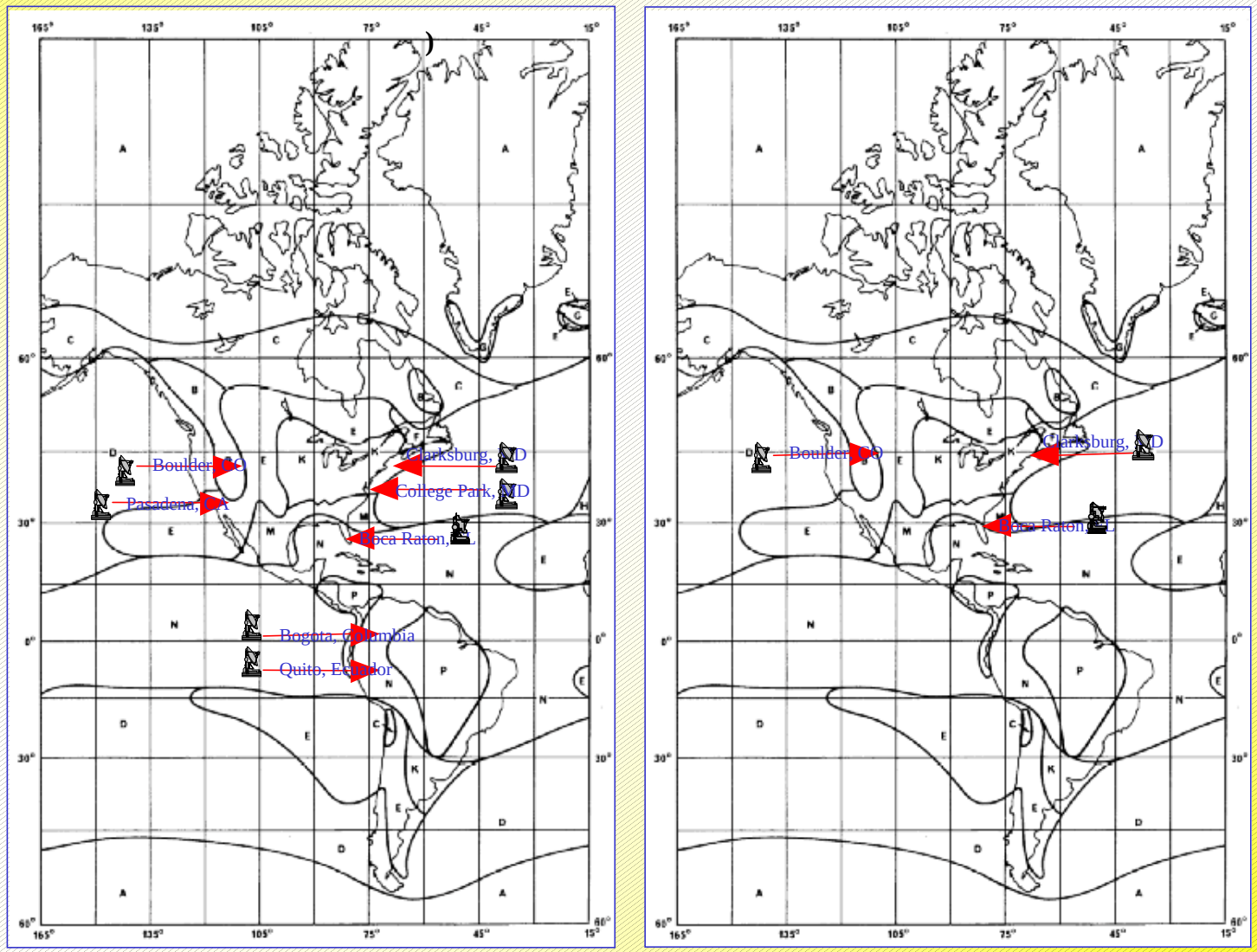
- **Rain fade depth**
  - Fade rate
  - Fade duration
  - Frequency scaling
  - Correlation of fade within 1 GHz band
  - Correlation of rain events over extended areas
- **Wet-antenna**
- **Depolarization**
  - Rain
  - Ice
- **Scintillation effects**
- **Gaseous absorption**

System Induced

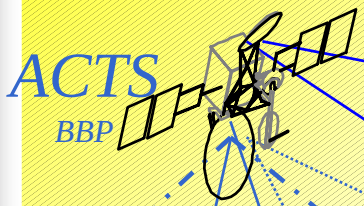
- **Ground Station**
  - Pointing error in rain
  - Snow accumulation
  - LNA stability
  - De-icers
- **Spacecraft**
  - Antenna pointing (Thermal)
  - Attitude control

Experiment Approach

VSAT Ground Station Locations
(Pre-Inclined and Inclined Orbit)



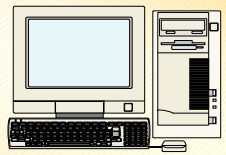
Experiment Description
VSAT Statistical Characterization I/O



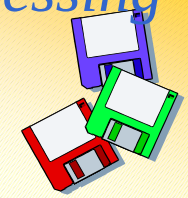
WS 08

NGS Data Processing

VAX-NGS



Chipper



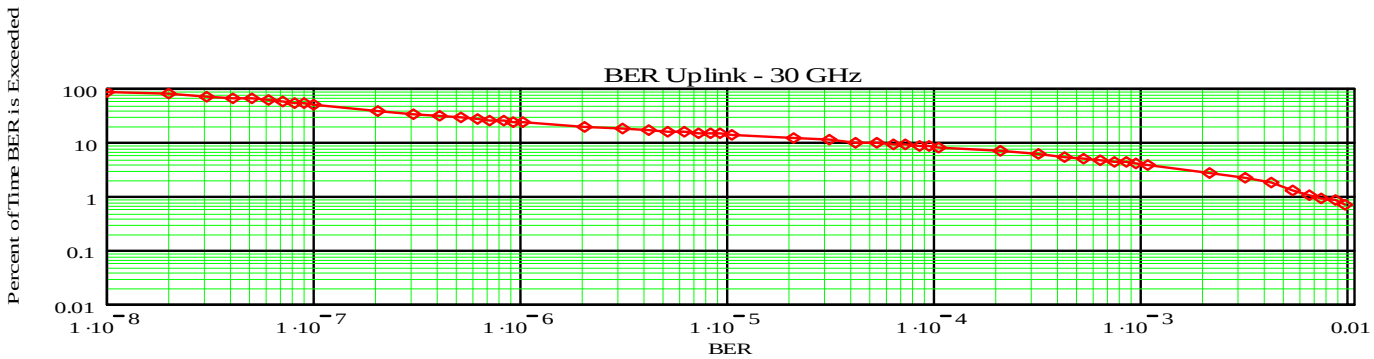
VSAT Files

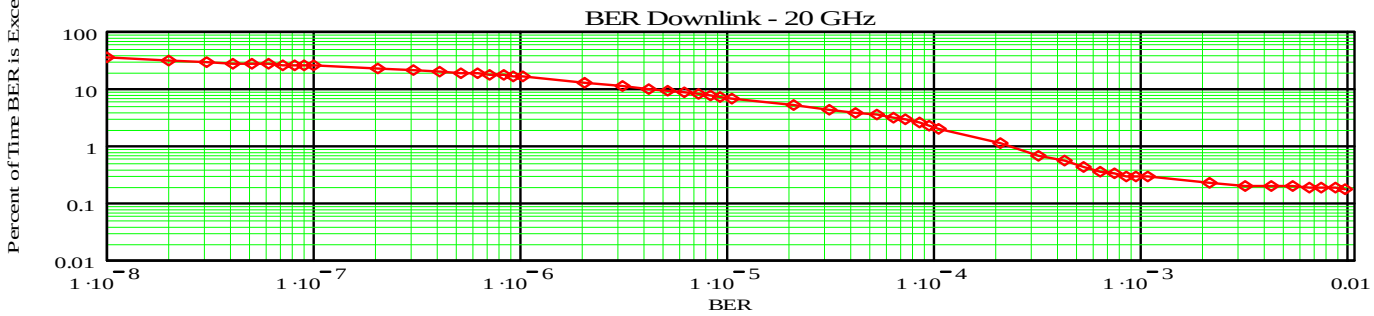
Example of Analysis

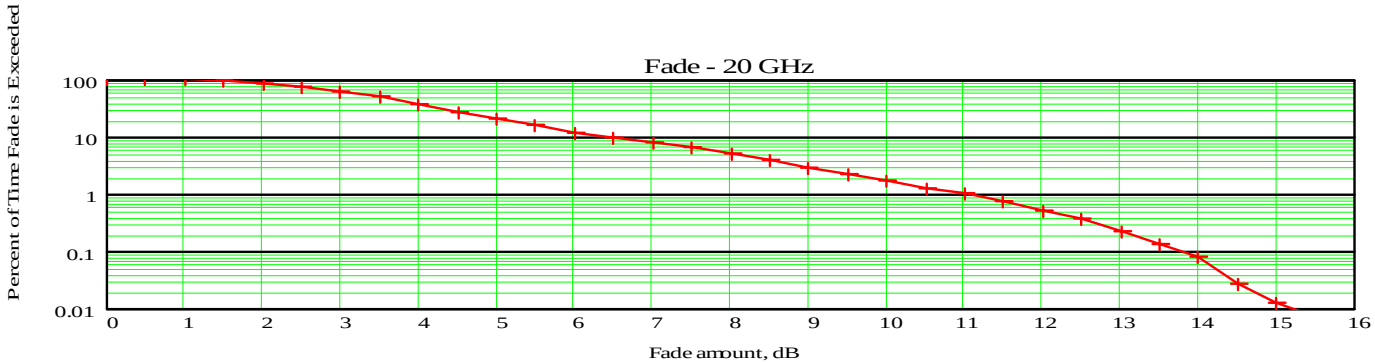
VSAT 9

Sep 98 - Jul 99

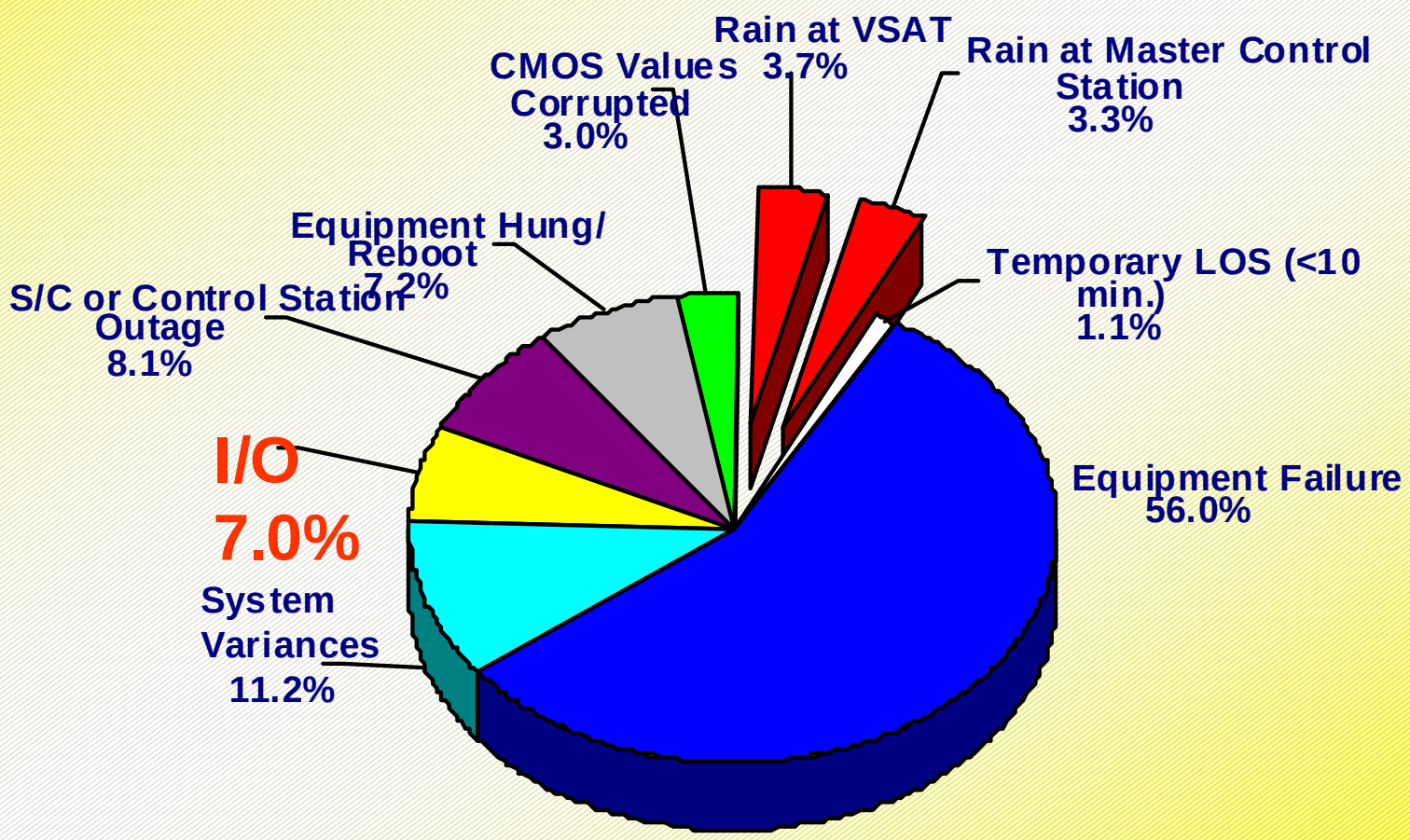
Medium Rain Zone - MD





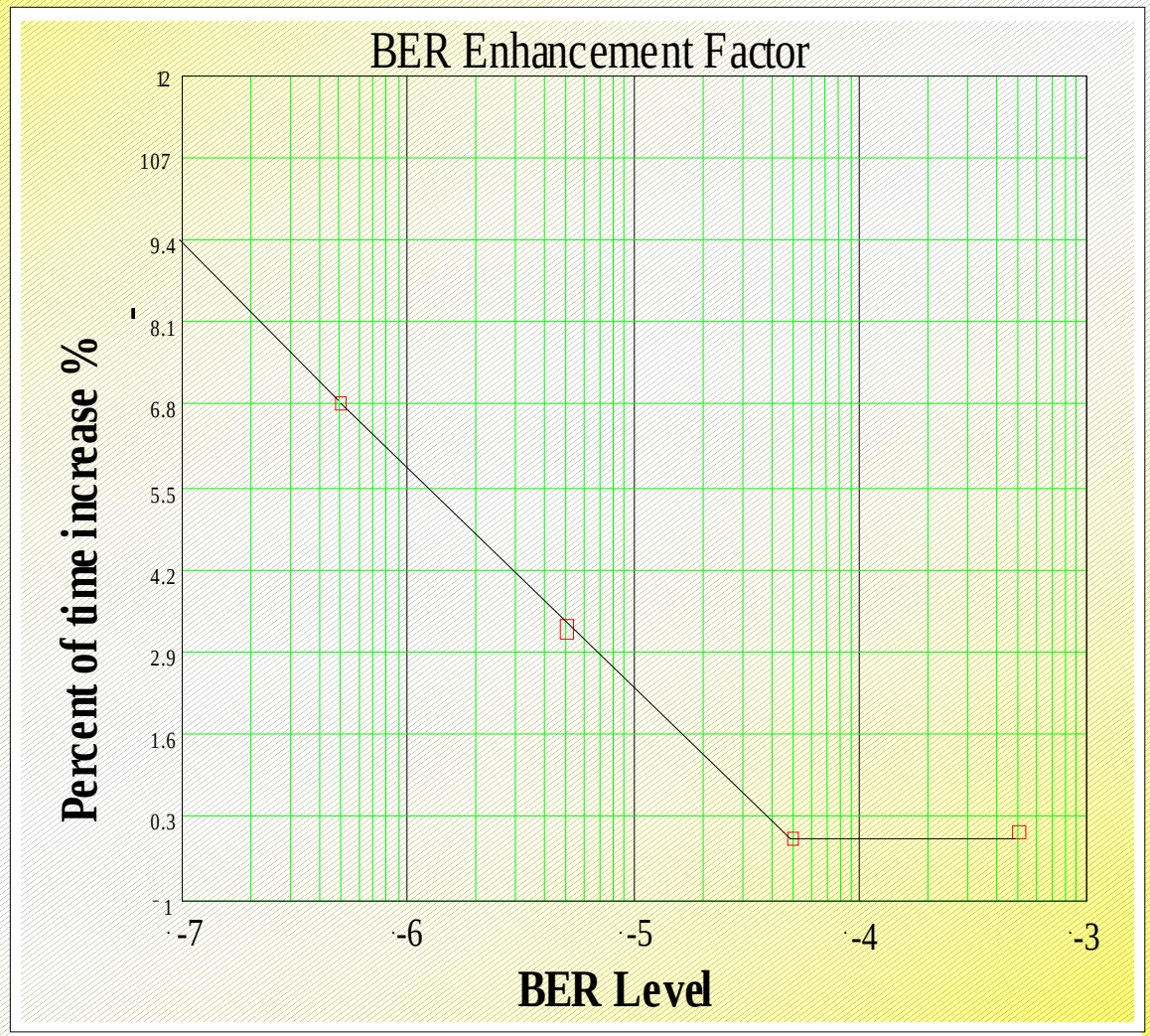


Results



System effects that result in lowering availability

Example of Analysis



Results

Approach

- **The effects of using rain fade compensation on improving system performance in a medium rain zone were statistically measured over a 1.5 year period**

Impact

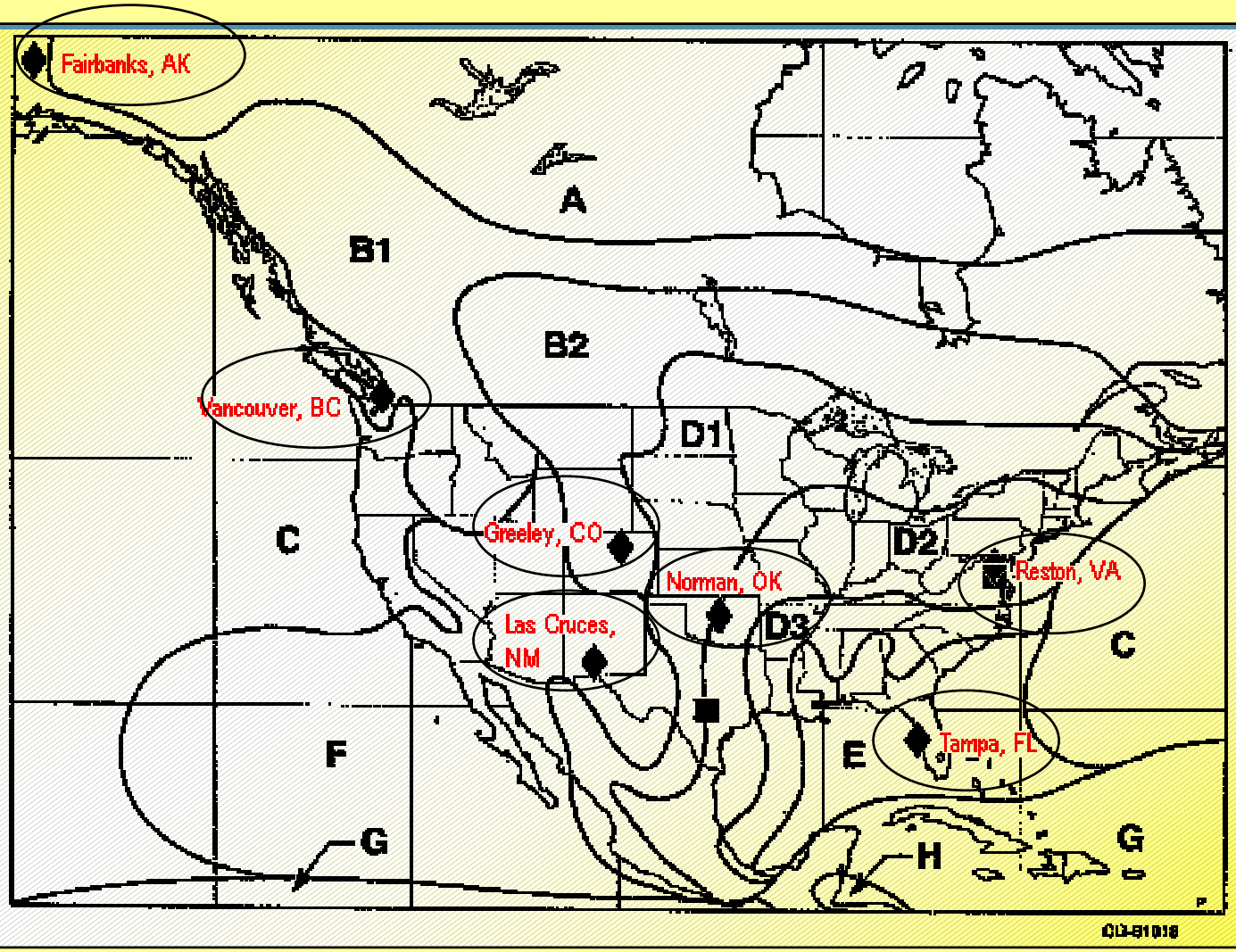
- **Fade compensation algorithm shows BER enhancement factor improved by about 9 % at a BER level of 10^{-7}.**
  - **For the coded station the BER of 10^{-7} was exceeded by 1 % of the time**
  - **For the un-coded station the BER of 10^{-7} was exceeded 10% of the time**

MODEL COMPARISON

Model	ITU Overall	ITU 15-35 GHz	ACTS 20 GHz	ACTS 27 GHz
DAH	1	2	1	1
ITU	2	3	3	4
ExCell	3		2	2
CCIR			5	5
Two Comp			4	3

Note: errors were 40% - 70%

Ka Band Measurements Sites



20 GHz and 30 GHz - 35 Station Years

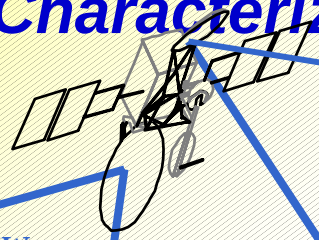
System Availability Results - Propagation

High Margin and Low Margin Systems

Test Location Margin	20 GHz 5 dB	20 GHz 20dB	30GHz 5dB	30GHz 20dB
Florida	99.165	99.852	98.475	99.709
Colorado	99.288	99.994	99.772	99.986
British Columbia	99.848	99.998	98.954	99.994
Alaska	98.984	99.997	98.667	99.984
Maryland	99.584	99.949	99.046	99.902
New Mexico	99.903	99.991	99.783	99.976
Oklahoma	99.612	99.955	99.071	99.892

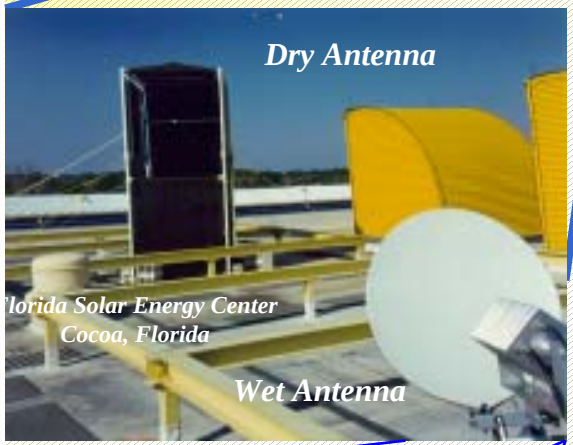
Experiment Description

Antenna Wetting Statistical Characterization

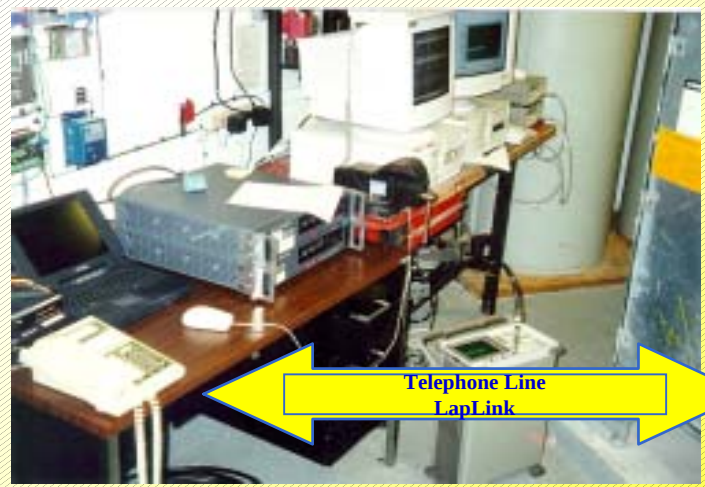


CW
@ 20 GHz

Cleveland Fixed Beam

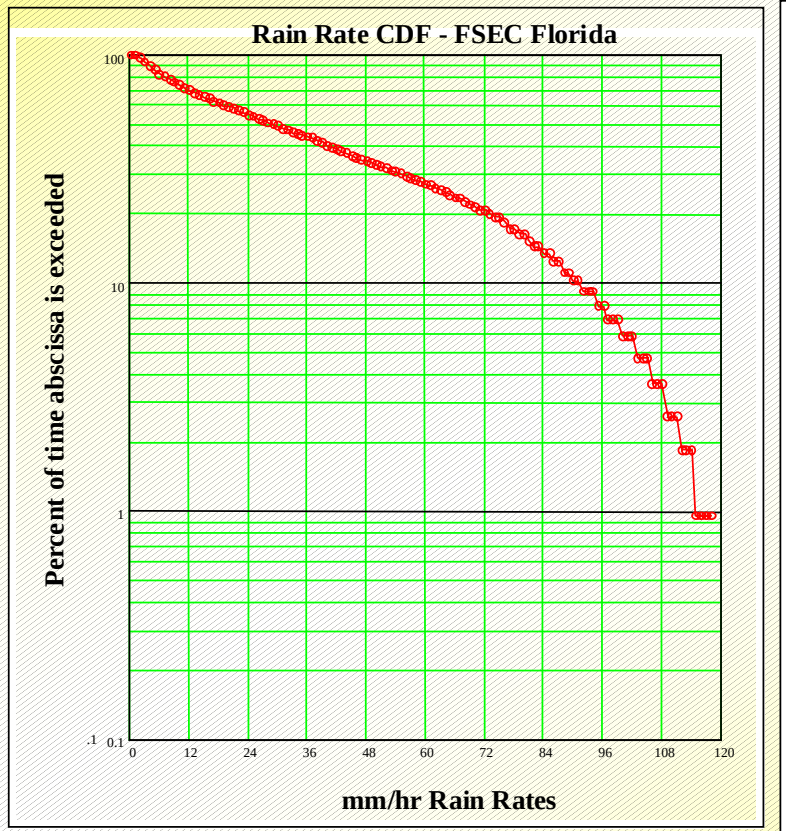


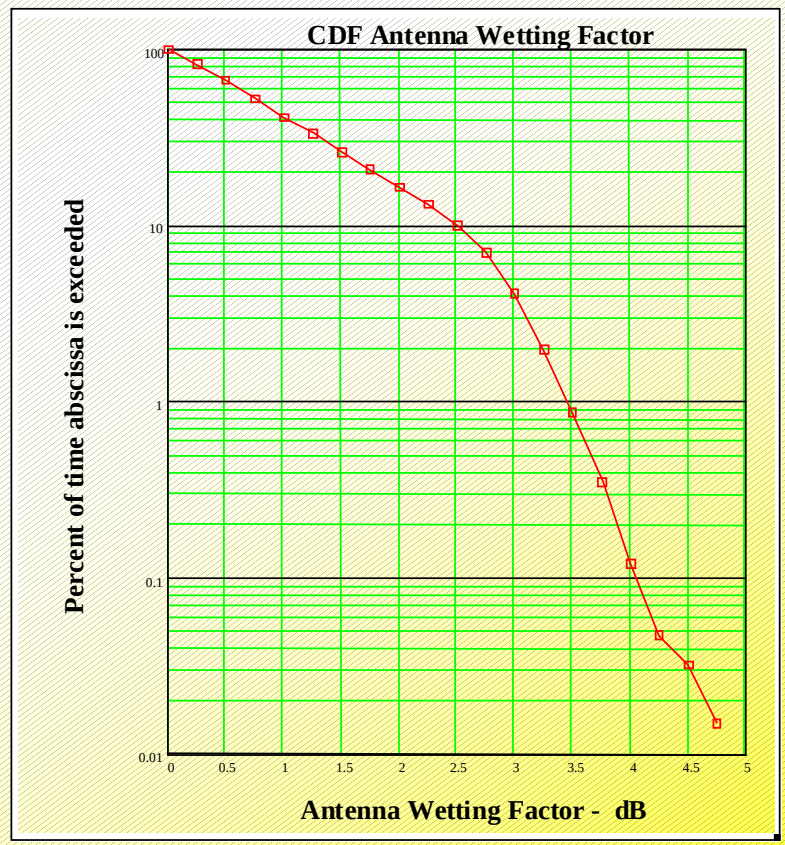
Data Processing



Data Analysis Center
(Remote RF DATAPC)

Example of Analysis

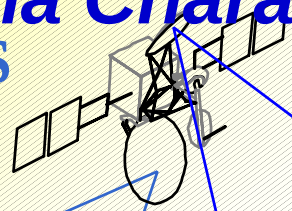




Results

- Statistically measured the effect of wet antenna surfaces on system margin at Ka band
- Measurements indicate an additional 2 dB of system margin required due to antenna wetting effects

Experiment Description
Multibeam Antenna Characterization I/O



Beam Characterization

Cleveland Fixed Beam

North-South
or
East-West
(Typically 50 miles apart)

Results

SUMMARY OF ALL MBA THERMAL EFFECTS

TYPE	*POLAR-IZATION*	*MAGNI-TUDE*	*DIRECTION (beam movement)*	*SYSTEM IMPACT*
Rapidly Varying (<1.5 Hrs)	V (East)	< 0.1 º	North South	Short term impact on marginal stations. Use ESA control during event to minimize impact
Diurnal Variations (<4 Hrs)	V & H (East, West)	< 0.2 º	East West	Significant signal variation can crash stations. Use biax drive to compensate
Quasi-static (<14 Hrs)	V & H (East, West)	<0.04 º <0.02 º	North-South East-West	Totally compensated by Autotrack
Vibration (1 Hz)	V & H (East, West)	< 0.015 º	East West	Generally negligible

http://acts.grc.nasa.gov/about/experiments/technology/

Technology Verification Experiments - Netscape

File Edit View Go Communicator Help

Back Forward Reload Home Search Netscape Print Security Stop

Bookmarks Location: http://kronos.lerc.nasa.gov/acts/tve.html What's Related

Technology Verification Experiments

The in-house ACTS TVEs are system characterization experiments and are defined as those experiments that can not be performed on the ground. The main TVEs for the last several years have been concentrated in the following areas: 1) Multibeam antenna characterization, 2) TIVSAT system availability, 3) TIVSAT rain fade compensation, 4) Antenna wetting, 5) Narrow angle diversity, 6) Uplink power control, 7) USAT characterization and 8) Ka-Band propagation modeling.

ACTS Home Page

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View/Download TVE Papers & TVE Presentations
System Availability
Rain Fade Compensation
Ka-Band Link Performance
Spacecraft Analysis

TVE Team Members
Roberto Acosta - Team Lead
William Gauntner
Charles S. Hall
Sandra Johnson
Kathy McEntee
Adesh Singhal

Email Related Questions or

The primary objective of Technology Verification Experiments (TVEs) is to obtain a deeper understanding and full characterization of Ka-Band sub systems (lessons learned) in the ACTS extended life operations.

Current TVE Research Areas

VSAT Statistical Performance in ACTS Fade Compensation Algorithm

Document: Done

CONCLUSIVE REMARKS

- Although rain is an important factor in determining availability, other significant factors unique to Ka band operations require attention.
- ACTS has demonstrated that adaptive rain fade compensation can be used to reliably and significantly improve VSAT margin and availability performance.
- Reflector Antennas need to be designed to minimize antenna wetting effects.
- Inclined orbit operations did not degrade the Multibeam antenna pointing.